PATENT SPECIFICATION

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555,134

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Complete Specification Accepted: Aug. 5, 1943.

PROVISIONAL SPECIFICATION

Improvements in or relating to Apparatus for Measuring Low Gas Pressure

I, OTTO ERNST HEINRICH KLEMPERER, a British Subject, usually known as Otto Klemperer, of 70, Syke Ings, Iver, Buckinghamshire, do hereby declare the nature of this invention to be as follows:—

The present invention relates to apparatus for measuring low gas pressure.

Apparatus for measuring low gas pressure down to 10^{-5} mm. mercury is known which includes an electron discharge device which is operated in the atmosphere of which the pressure is to be measured and which comprises a pair of cathodes for the emission of electrons and an anode for collecting electrons emitted from the cathodes, means being provided for establishing a strong magnetic field substantially perpendicular to the cathodes and to which the anode presents a small collecting surface perpendicular to the direction of the field. In this arrangement electrons emitted from the cathodes are caused to travel along spiral paths from one cathode towards the other, the axes of the spirals being almost parallel to the lines of force in the magnetic field, the electrons being reflected repeatedly to and fro through the magnetic field before reaching the anode. In such apparatus the current between the cathodes and anode in the electron discharge device affords an indication of the pressure of the gas in which the device is immersed. Typical electrode arrangements in electron discharge devices employed in apparatus of this kind are represented diagrammatically in Figures 1*a*, 1*b* and 1*c* of the accompanying drawing, each of which figures shows the arrangement of electrodes in one form of device.

In the form shown in Figure 1*a*, two plain disc-shaped cathodes C_1 and C_2 are disposed facing each other with the collecting anode A of cylindrical form represented in section surrounding them. A strong magnetic field is set up between the cathodes as indicated by the arrow H which is coincident with the axis of the electrode system. This field is not necessarily absolutely uniform, but is approximately so.

In the form shown in Figure 1*b* a pair of annular cathodes C_1 and C_2 are employed with an anode A of rod form extending axially through the central apertures of the cathodes. In this case the magnetic field extends substantially parallel to the anode A.

In the form shown in Figure 1*c* the cathodes C_1 and C_2 are similar to those shown in Figure 1*a*, but the anode A is a simple ring disposed midway between the cathodes.

The object of the present invention is to provide improved apparatus for measuring low gas pressure of the kind in which an indication of the gas pressure may be obtained by measuring the current flowing between the cathode and anode of an electron discharge device, and which will afford an indication of gas pressure below 10^{-5} mm. mercury.

According to one feature of the present invention, apparatus for measuring low gas pressure is provided comprising an electron discharge device adapted to be immersed in the atmosphere of which the pressure is to be measured, said device including a cathode and an anode in which said anode is substantially completely surrounded by said cathode so as to be well shielded electrostatically by the cathode, and means for causing electrons to travel in long paths between said anode and said cathode so that sufficient ionisation takes place in said gas to produce a desired indicating current.

In accordance with a further feature of the invention, apparatus for measuring low gas pressure is provided of the kind in which an electron discharge device is employed which is immersed in the atmosphere of which the pressure is to be measured and which comprises at least a cathode and an anode and means for causing electrons to travel in long paths between said cathode and said anode, wherein an electrode, preferably said anode, is contaminated with or has a superficial coating of radio-active material so disposed that said material will come in contact with the atmosphere

[Price 1/-]

of which the pressure is to be measured when the apparatus is in use.

In the preferred form of the invention the electrode arrangement of which is illustrated in Figure 2 of the accompanying drawing, the anode A is of rod form coated with radio-active material such as thorium oxide, and the cathode C comprises two plain annular diaphragms C_1 and C_2 disposed about the anode in the manner illustrated in Figure 1*b* above, but mounted one at each end of a cylindrical member of conducting material which forms with the annular diaphragms C_1 and C_2 a complete shield for the collecting portion of the rod anode.

In order to afford the desired indication of gas pressure the electrodes of Figure 2 may be set up in the manner shown in Figure 3 of the accompanying drawing within an envelope or tube T having a cylindrical bulb portion embracing the cathode C and fed with gas of which the pressure is to be measured through a tube V. A solenoid M is disposed substantially co-axially with the cathode C for providing an axial magnetic field for causing electrons to traverse long paths through the gas in the manner described above. In operation, the electron discharge device is energised from a suitable high tension source HT which is connected to the anode A, through a load resistance R, and a microammeter μA may be connected in the cathode lead for measuring the desired current, while a voltmeter KV, preferably reading in kilovolts, is provided for measuring the voltage between the anode and cathode.

When a discharge device of the kind shown in Figure 2 is employed the shielding which is afforded by the cathode eliminates detrimental effects arising from field disturbances due to electrostatic charges which develop on the glass walls of the housing T (Figure 3) when the apparatus is in operation. Furthermore, any sputtering from the anode, which occurs during the operation of the device only serves to cause deposition of the metal on the cathode where it is quite harmless, whereas in the case where the anode A is unshielded, sputtered metal from the anode is deposited on the glass wall of the envelope and there constitutes a source of disturbance for the field within the device.

It is preferred to provide a solenoid for establishing a magnetic field within the device rather than to employ a permanent magnet arrangement. With the solenoid, current through the coil can be readily switched off when it is not required to use the apparatus for pressure measurements so that the magnetic field can be easily removed at will, and will not interfere unnecessarily with the operation of equipment to which the apparatus is connected.

It is preferred to employ the device of the form shown in Figure 2, corresponding to the known type of device shown in Figure 1*b*, rather than to employ a device corresponding to such a type as that shown in Figure 1*a* or 1*c*, as it is found that devices of the form shown in Figures 1*a* and 1*c* are more sensitive in respect of fluctuations of the magnetic field than devices of the type shown in Figure 1*b* and Figure 2.

In a typical example of apparatus according to the invention, a device of the form shown in Figure 2 was employed in which the cathode C consisted of a cylinder of 1½" (3.8 cm.) diameter formed of "Eureka" (Registered Trade Mark) with two apertured diaphragms in its end 60 mm. apart, the apertures in the diaphragms being 6 mm. in diameter. The anode A was a tungsten wire of 1 mm. diameter activated by being dipped in thorium nitrate solution and warmed up gently so as to provide a thin radio-active coating of thorium oxide on the surface of the anode. This device was included in an arrangement of the form shown in Figure 3, wherein the solenoid M was arranged to produce a field of about 260 oersted along the axis of the device. The voltage applied to the anode A from the source HT. was in some cases as high as 8 KV. Gas pressure can be determined by observation of the reading of the microammeter μA.

It is found that in apparatus for measuring gas pressure including devices of the kind set forth above, if at least a part of one of the electrodes in the device has a portion contaminated or coated with radio-active material, said portion coming in contact with the atmosphere in which the device operates, it is found that the device can be put into operation in atmospheres in which the gas pressure is below 10^{-5} mm. mercury, much more rapidly and certainly than is the case when none of the electrodes are so contaminated or coated. In the case of apparatus employing a device having clean uncontaminated electrodes operating at gas pressures below that mentioned, great difficulty may be experienced in causing the discharge to commence, the device sometimes remaining quiescent while the operating potentials are applied for periods of from five to ten minutes' duration at the end of which the discharge suddenly commences. This is, of course, objectionable in cases where the apparatus is required to give readings rapidly. However, if one of the electrodes is contamin-

ated or coated with radio-active material in the manner suggested above, the radio-active material emits α or β rays continuously, which ionise the gas sufficiently so that when operating potentials are applied to the electrodes, the device primes with not more than a few seconds delay.

In the apparatus described in detail by way of illustration it was found that for small currents up to about 50 microamps the current passed by the discharge through the device was proportional to the gas pressure in the device; for larger currents, however, it was found that, as the gas pressure increased, the current increased rather more rapidly than the gas pressure. Thus for practical use apparatus according to the invention must be calibrated and a calibration curve finished. A series of such curves can be provided for any particular apparatus, the various curves corresponding to various sensitivity ranges.

In employing apparatus according to the invention it has been found that when very high discharge currents are produced the device tends to absorb an appreciable amount of gas, the amount of absorption being uncontrollable. Thus, it is preferred to operate the apparatus by noting the anode voltage required to produce a fixed small discharge current, for example, 10 microamps, and the indication of the meter KV is used to afford the indication of the gas pressure. Two typical calibration curves are shown by I and II in Figure 4, in which anode voltage is indicated vertically in kilovolts and gas pressure in mμ mercury (that is mm. mercury $\times 10^{-6}$), the abscissæ for curve I being shown in the scale above the curve and the abscissæ for curve II being shown in the scale below the curve, all the scales being logarithmic. The form of the curves I and II is represented with about 30 per cent. accuracy by the empirical formula $p = \dfrac{I}{a(V-b)}$, where p is the pressure mμ of mercury, I is the current passed by the discharge device in microamps, V is the anode voltage in kilovolts and a and b are constants which for the particular example described above were found to be 2 and 1 respectively.

The form of calibration curve was found to be little affected by changes in the diameter of the anode, the internal diameter of the diaphragms C_1 and C_2 and the diameter of the cylinder Z or the strength of the magnetic field.

Apparatus according to the invention is particularly suitable for measuring the vacuum in a tube which is being exhausted and, unlike the McLeod gauge, it may be employed to indicate vapour pressure as well as gas pressure.

As compared with the hot filament-type of ionisation gauges, gauges of the kind to which the present invention relates appear to have the advantage of not needing careful degassing by baking or eddy-current heating of the electrodes. After being evacuated from atmospheric pressure, these gauges may be degassed sufficiently by running them for about a minute in good vacuum such as the vacuum to be measured with comparatively large currents of about 1 milliamp.

Dated this 2nd day of February, 1942.
F. W. CACKETT,
Chartered Patent Agent.

COMPLETE SPECIFICATION

Improvements in or relating to Apparatus for Measuring Low Gas Pressure

I, OTTO ERNST HEINRICH KLEMPERER, a British Subject, usually known as Otto Klemperer, of 70, Syke Ings, Iver, Buckinghamshire, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to apparatus for measuring low gas pressure.

Apparatus for measuring low gas pressure down to 10^{-5} mm. mercury is known, see, for example, Patent Specification No. 474,845, which includes an electron-discharge device which is operated in the atmosphere of which the pressure is to be measured and which comprises a pair of electrodes which serve as cathodes for the emission of electrons and an electrode which serves as an anode for collecting electrons emitted from the cathodes, means being provided for establishing a strong magnetic field substantially perpendicular to the cathodes and to which the anode presents a small collecting surface perpendicular to the direction of the field. In this arrangement the cathode is heated by ionic bombardment was to

cause the emission of electrons therefrom the electrons emitted from the cathodes are caused to travel along helical paths from one cathode towards the other, the axes of the helices being almost parallel to the lines of force in the magnetic field, the electrons being reflected repeatedly to and fro through the magnetic field and finally reaching the anode. In such apparatus the current between the cathodes and anode in the electron-discharge device affords an indication of the pressure of the gas in which the device is immersed. Typical electrode arrangements in electron-discharge devices employed in apparatus of this kind are represented diagrammatically in Figures 1*a*, 1*b* and 1*c* of the drawing accompanying the Provisional Specification.

In the form shown in Figure 1*a*, two plain disc-shaped cathodes C_1 and C_2 are disposed facing each other with the collecting anode A of cylindrical form represented in section surrounding them. A strong magnetic field is set up between the cathodes as indicated by the arrow H which is coincident with the axis of the electrode system. This field is not necessarily absolutely uniform, but is approximately so.

In the form shown in Figure 1*b* a pair of annular cathodes C_1 and C_2 are employed with an anode A of rod form extending axially through the central apertures of the cathodes. In this case the magnetic field extends substantially parallel to the anode A.

In the form shown in Figure 1*c* the cathodes C_1 and C_2 are similar to those shown in Figure 1*a*, but the anode A is a simple ring disposed midway between the cathodes. In this case the magnetic field extends substantially axially of the anode.

The object of the present invention is to provide improved apparatus which will afford an indication of gas pressure below 10^{-5} mm. mercury.

According to one feature of the present invention, apparatus for measuring low gas pressure is provided comprising an electron-discharge device adapted to be immersed in the gas of which the pressure is to be measured, said device including a first electrode capable of serving as a cathode and a second electrode capable of serving as an anode and means for causing electrons to travel in long paths between said first electrode and said second electrode so that sufficient ionisation takes place in said gas to produce a desired indicating current, said first electrode being in the form of a substantially closed shell and said second electrode extending within said shell so that the space in which said ionisation is produced is electrostatically shielded by said first electrode.

In accordance with a further feature of the invention, apparatus for measuring low gas pressure is provided of the kind in which an electron-discharge device is employed which is adapted to be immersed in the gas of which the pressure is to be measured, said device including a first electrode capable of serving as a cathode and a second electrode capable of serving as an anode and means for causing electrons to travel in long paths between said first electrode and said second electrode for producing sufficient ionisation in said gas to afford said indicating currents, said device having radio-active material so disposed that radiation from said material will enter the space within which said ionisation takes place.

In order that the invention may be clearly understood and readily carried into effect, the same will now be more fully described with reference by way of example to Figures 2, 3 and 4 of the drawing accompanying the Provisional Specification wherein:

Figure 2 is a diagrammatic representation of an improved electrode arrangement in accordance with the present invention;

Figure 3 is a diagrammatic representation of the electrical circuit of apparatus according to the invention; and

Figure 4 shows characteristic curves obtained in operating the apparatus forming the subject of Figure 3; and reference will also be made to the accompanying drawing of which the Figures are numbered 5, 6 and 7 for convenience and each show a suitable electric circuit arrangement for use with apparatus in accordance with the present invention.

In the electrode arrangement illustrated in Figure 2 of the drawing accompanying the Provisional Specification, the electrode A which serves as the anode is of rod form and the electrode C which serves as the cathode comprises two plain annular diaphragms C_1 and C_2 disposed about the anode in the manner illustrated in Figure 1*b* above, but mounted one at each end of a cylindrical member Z of conducting material which forms with the annular diaphragms C_1 and C_2 a complete shield for the collecting portion of the anode A. The anode A is coated with radio-active material such as thorium oxide.

In order to afford the desired indication of gas pressure the electrodes of Figure 2 may be set up in the manner shown in Figure 3 of the drawing accom-

panying the Provisional Specification within an envelope or tube T having a cylindrical bulb portion which embraces the cathode C and is connected with the space in which the gas pressure is to be measured through a tube V. A solenoid M is disposed substantially co-axially with the cathode C for providing an axial magnetic field for causing electrons to traverse long paths through the gas in the manner described above. The anode A is connected through a load resistance to the positive pole of a high tension source H.T., the negative pole of which is earthed, the cathode C is earthed, and a microammeter μA may be connected in the cathode lead for measuring the desired current, while a voltmeter KV, preferably reading in kilovolts, is provided for measuring the voltage between the anode and cathode.

When a discharge device of the kind shown in Figure 2 is employed the shielding which is afforded by the cathode eliminates detrimental effects arising from field disturbances due to electrostatic charges which develop on the glass walls of the housing T (Figure 3) when the apparatus is in operation. Furthermore, any sputtering from the anode, which occurs during the operation of the device only serves to cause deposition of the metal on the cathode where it is quite harmless, whereas in the case where the anode A is unshielded, sputtered metal from the anode is deposited on the glass wall of the envelope and there constitutes a source of disturbance for the field within the device.

It is preferred to provide a solenoid for establishing a magnetic field within the device rather than to employ a permanent magnet arrangement, because with the solenoid, current through the coil can be readily switched off when it is not required to use the apparatus for pressure measurements. Thus the magnetic field can be easily removed at will, and will not interfere unnecessarily with the operation of equipment to which the apparatus is connected.

It is preferred to employ the device of the form shown in Figure 2, corresponding to the known type of device shown in Figure 1*b*, rather than to employ a device corresponding to a type such as that shown in Figure 1*a* or 1*c*, as it is found that devices of the form shown in Figures 1*a* and 1*c* are more sensitive in respect of fluctuations of the magnetic field than devices of the type shown in Figure 1*b* and Figure 2.

In a typical example of apparatus according to the invention, a device of the form shown in Figure 2 was employed in which the cathode C consisted of a cylinder of 3.8 cm. diameter formed of "Eureka", Registered Trade Mark, with two apertured diaphragms in its end 60 mm. apart, the apertures in the diaphragms being 6 mm. in diameter. The anode A was a tungsten wire of 1 mm. diameter activated by being dipped in thorium nitrate solution and warmed up gently so as to provide a thin radio-active coating of thorium oxide on the surface of the anode. This device was included in an arrangement of the form shown in Figure 3, wherein the solenoid M was arranged to produce a field of about 260 oersted along the axis of the device. The voltage applied to the anode A from the source HT was in some cases as high as 8 KV. Gas pressure can be determined by observation of the reading of the microammeter μA.

It is found that if at least a part of one of the electrodes in the device has a portion within the space in which ionisation occurs contaminated or coated with radio-active material, the device can be put into operation in atmospheres in which the gas pressure is below 10^{-5} mm. mercury much more rapidly and certainly than is the case when none of the electrodes are so contaminated or coated. For example, in the case of apparatus employing a device having clean uncontaminated electrodes operating at gas pressures below that mentioned, great difficulty may be experienced in causing the discharge to commence, the device sometimes remaining quiescent while the operating potentials are applied for periods of from five to ten minutes' duration, at the end of which the discharge suddenly commences. This is, of course, objectionable in cases where the apparatus is required to give readings rapidly. However, if one of the electrodes is contaminated or coated with radio-active material in the manner suggested above, the radio-active material emits α or β rays continuously, and these rays ionise the gas sufficiently so that when operating potentials are applied to the electrodes, the device primes with not more than a few seconds' delay.

In the apparatus described in detail by way of illustration it was found that for small currents up to about 50 microamps the current passed by the discharge through the device was proportional to the gas pressure in the device; for larger currents, however, it was found that, as the gas pressure increased, the current increased rather more rapidly than the gas pressure. Thus for practical use apparatus according to the invention must be calibrated and a calibration curve

furnished. A series of such curves can be provided for any particular apparatus, the various curves corresponding to various sensitivity ranges.

In employing apparatus according to the invention it has been found that when very high discharge currents are produced the device tends to absorb an appreciable amount of gas, the amount of absorption being uncontrollable. Thus, it is preferred to operate the apparatus by noting the anode voltage required to produce a fixed small discharge current, for example, 10 microamps, and the indication of the meter KV is used to afford the indication of the gas pressure. Two typical calibration curves are shown by I and II in Figure 4, in which anode voltage is indicated vertically in kilovolts and gas pressure in μmms. mercury (that is mms. mercury $\times 10^{-6}$) is indicated horizontally, the abscissæ for curve I being shown in the scale above the curve and the abscissæ for curve II being shown in the scale below the curve, all the scales being logarithmic. The form of the curves I and II is represented with about 30 per cent. accuracy by the empirical formula $p=\frac{I}{a(V-b)}$, where p is the pressure in μmms. of mercury, I is the current passed by the discharge device in microamps, V is the anode voltage in kilovolts and a and b are constants which for the particular example describe above were found to be 2 and 1 respectively.

The form of the calibration curve was found to be little affected by changes in the diameter of the anode, the internal diameter of the diaphragms C_1 and C_2 and the diameter of the cylinder Z or the strength of the magnetic field.

Apparatus according to the invention is particularly suitable for measuring the vacuum in a tube which is being exhausted and, unlike the McLeod gauge, it may be employed to indicate vapour pressure as well as gas pressure.

As compared with the hot filament-type of ionisation gauge, gauges of the kind to which the present invention relates appear to have the advantage of not needing careful degasing by baking or eddy-current heating of the electrodes. After being evacuated from atmospheric pressure, these gauges may be degased sufficiently by running them for about a minute in good vacuum such as the vacuum to be measured with comparatively large currents of about 1 milliamp.

The arrangement illustrated in Figure 3 has the disadvantage that the microammeter μA is arranged in the cathode circuit of the pressure measuring device. As this is fed from a very high voltage source, the microammeter is liable to be subject to excessive voltage and be burnt out. Accordingly it is preferred to employ, in conjunction with a measuring device in accordance with the invention, measuring or indicating circuits such as those shown in Figures 5, 6 and 7 of the accompanying drawing, in which the microammeter is replaced by a cheaper and more robust milliammeter which is protected from excessive voltages or in which a current reading instrument is dispensed with completely.

In the circuit illustrated in Figure 5 of the drawing the anode of the device according to the invention is connected directly to the positive pole of the high tension source which is not shown, but which is represented by the plus sign in the drawing, the cathode of the device being connected to earth through a high resistance N of 5 megohms and the load resistance R which may have, for example, a resistance of 100,000 ω. The resistance N is provided for safety. The junction of resistances N and R is connected to the control cathode of a variable-mu valve V_1 in the cathode lead of which the microammeter mA is connected. The anode of the valve V_1 is connected to a source of positive potential through a suitable load resistance R_1 and may be provided with a suitable grid-biasing arrangement, not shown in the drawing. With the arrangement of Figure 5, if the measuring device AC is operated at constant voltage the whole range of gas pressures between about 10^{-3} and 10^{-6} mm. mercury can be read on the scale of the milliammeter mA, and the arrangement can be used for affording a rapid indication of the state of the vacuum to be measured.

In the arrangement shown in Figure 6 the circuit of the device AC is similar to that shown in Figure 5, but the load resistance R is given a higher value, for example, it may be of the order of a megohm and the cathode C is connected through resistance S of the order of a megohm, provided for safety reasons, to the control-grid of a high slope triode valve V_2 of which the cathode lead includes a milliammeter mA in series with an adjustable load resistance R_2 of 10,000 ohms approximately.

It will be seen that in the arrangement of Figure 6 the valve V_2 is connected so as to operate as a cathode follower valve. Thus the potential of the cathode of valve V_2 will follow that of the control grid of the valve and will be substantially the same as that of the junction of resistance N and resistance R. The current through

resistance R_2 and milliammeter mA will thus be substantially proportional to but many times larger than the current through the measuring device AC. To afford an indication of the desired vacuum it is preferred to provide a voltmeter such as KV in Figure 3 for indicating the voltage across the measuring device, this voltage being adjusted till the milliammeter mA gives the partiular indication corresponding to a current of 10 microamperes through the device. This arrangement is preferably first calibrated with a microammeter corresponding to the microammeter μA of Figure 3 in series with the device AC, the microammeter being subsequently removed from circuit.

If desired, the current measuring instrument mA of Figure 6 may be dispensed with and a visual indicator employed instead as shown in Figure 7. In this case the cathode C of the device AC is connected through a large protective resistance S, again of the order of a megohm, to the grid of a triode valve V_3, the anode of which is connected to a source of positive potential of the order of, for example, 200 volts, through an anode load resistance R_1 which may be of 100,000 ohms. Connected between the anode of valve V_3 and earth is a potentiometer resistance P, which may be of the order of 4 megohms. The visual indicator ME, which may be a visual tuning indicator of the kind known as a "Magic Eye", such as is described, for example, in specification No. 481,790, is connected to a tapping on the potentiometer resistance P, the tapping being arranged so that the annular luminous pattern on the device ME just closes when the current through the gauge AC has a particular value, for example, 5 microamps, and the gas pressure is determined by measuring the voltage across the gauge AC when the pattern on the indicator ME just closes. It is preferred to operate the device ME to cause the pattern just to close when the desired current is passing through the gauge rather than to cause the pattern to contract as it normally does to afford a resonance indication in a radio receiver, since a more critical adjustment can be obtained when the pattern is caused to close. As in the case of the arrangement of Figure 6, the arrangement of Figure 7 should be calibrated with a microammeter in series with the device AC, and a jack J may be provided to enable the microammeter to be inserted in the circuit whenever it is desired to do so for the purpose of recalibration. Furthermore, in the arrangement of Figure 7 no voltmeter such as KV of Figure 6 is provided for measuring the voltage across the device AC, but the current for the device is fed from a high voltage source PU, the primary circuit of which may include, for example, the primary winding of a transformer of appropriate step-up ratio, and the voltage applied to this circuit is derived from a potentiometer IP of which the position of the slider is observed against a scale which may be calibrated to indicate directly gas pressure in the gauge in mm. mercury. Preferably the potentiometer IP is so wound or otherwise formed that at low voltages the rate of voltage variation with movement of the slider is less than at high voltages. The power unit PU may be fed from a suitable mains supply SO, the voltages or the tapping of potentiometer IP thus being quite low.

With the arrangement of Figure 7 it may be necessary to check the calibration of potentiometer IP from time to time and this may be done by inserting the microammeter in the jack J. The slider on potentiometer IP is then adjusted so that when indicator ME affords the desired indication, the position of slider on potentiometer IP indicates a gas pressure corresponding to a known gas pressure in the device AC.

I am aware that in the specification of Patent No. 474,845 apparatus including a device of the form shown in Figure 1c of the drawing accompanying the Provisional Specification of the present application is described in detail and it is stated in the prior specification that a device can be employed having co-axial cylindrical electrodes. However, in the prior patent specification it is not suggested that the cathode should surround the anode, neither is it suggested that the cathode should be in the form of a substantially closed shell.

I am also aware that in patent specification No. 493,274 which is a patent of addition to Patent No. 474,845 the cathode of the device consists at least partly of thorium or zirconium. This is said to increase the sensitivity of the apparatus and make the cathode ignite more easily. It is to be understood that in the present case claim 2 is to be read as excluding apparatus having a cathode formed wholly or partly of thorium or zirconium.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. Apparatus for measuring low gas pressure comprising an electron-discharge device adapted to be immersed in the gas

of which the pressure is to be measured, said device including a first electrode capable of serving as a cathode and a second electrode capable of serving as an anode and means for causing electrons to travel in long paths between said first electrode and said second electrode for producing ionisation in said gas to afford an indicating current, said first electrode being in the form of a substantially closed shell and said second electrode extending within said shell so that the space in which said ionisation is produced is electrostatically shielded by said first electrode.

2. Apparatus for measuring low gas pressure comprising an electron-discharge device adapted to be immersed in the gas of which the pressure is to be measured, said device including a first electrode capable of serving as a cathode and a second electrode capable of serving as an anode and means for causing electrons to travel in long paths between said first electrode and said second electrode for producing ionisation in said gas to afford an indicating current, said device having radio-active material so disposed that radiation from said material will enter the space within which said ionisation takes place.

3. Apparatus according to Claim 1 or 2, wherein said first electrode is of cylindrical form having its ends substantially closed by two diaphragms said second electrode extending within said first electrode co-axially therewith.

4. Apparatus according to any of the preceding claims, including an indicating device for indicating the current through said device and arranged so as not to be traversed by said current.

5. Apparatus according to Claim 4, wherein said indicating device is connected in the output circuit of an electron-discharge device which is arranged to respond to said current.

6. Apparatus according to Claim 4 or 5, wherein said indicating device is capable of affording a particular indication when said current is of a predetermined value and indicating means are provided for affording an indication related to the voltage applied between said first electrode and said second electrode, said indicating means being arranged to be adjusted to vary said voltage to cause said indicating device to afford said particular indication which is independent of the gas pressure, the setting of said indicating means when so adjusted then affording an indication of the pressure to be measured.

7. Apparatus according to Claim 6, wherein said indicating device is an indicator of the magic eye type.

8. Apparatus for measuring low gas pressure substantially as herein described with reference to and as shown in Figures 2 and 3 of the drawing accompanying the Provisional Specification said apparatus including if desired an indicating circuit substantially as herein described with reference to Figure 5, 6 or 7 of the accompanying drawing.

Dated this 29th day of January, 1943.

F. W. CACKETT,
Chartered Patent Agent.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1943

555,134 PROVISIONAL SPECIFICATION

1 SHEET

[This Drawing is a reproduction of the Original on a reduced scale.]

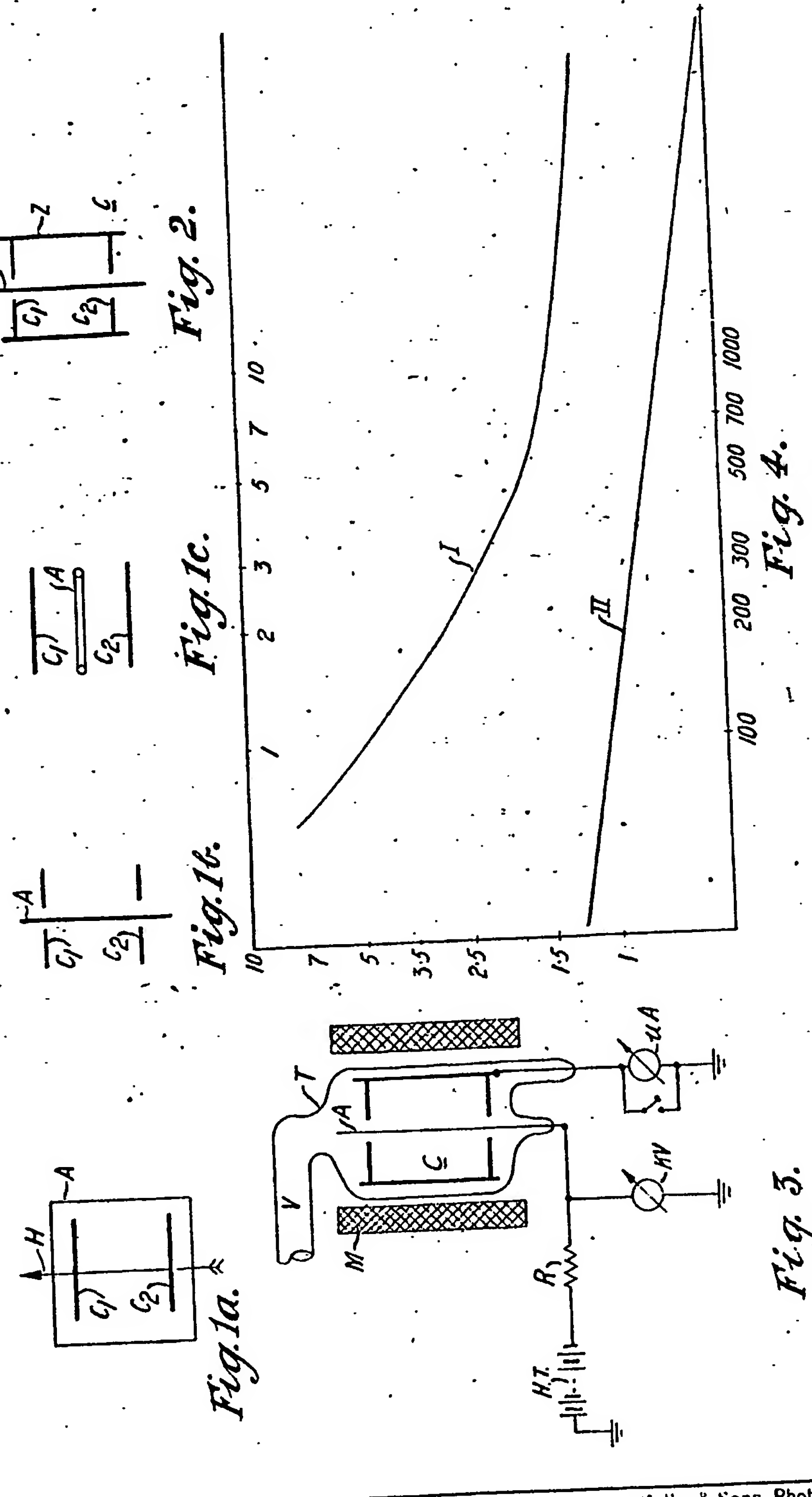

Fig. 1a.

Fig. 1b.

Fig. 1c.

Fig. 2.

Fig. 3.

Fig. 4.

Malby & Sons, Photo-Litho.

[This Drawing is a reproduction of the Original on a reduced scale.]

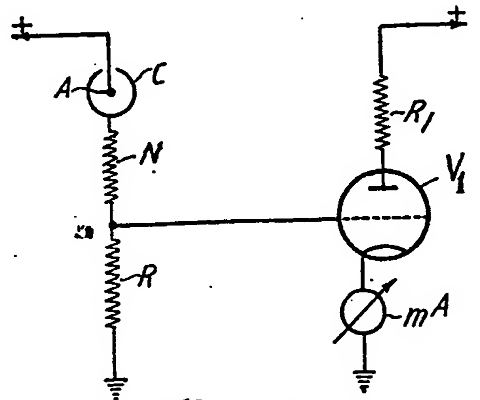

Fig. 5.

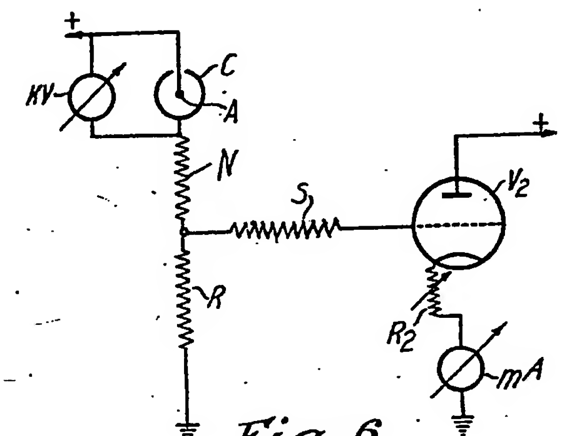

Fig. 6.

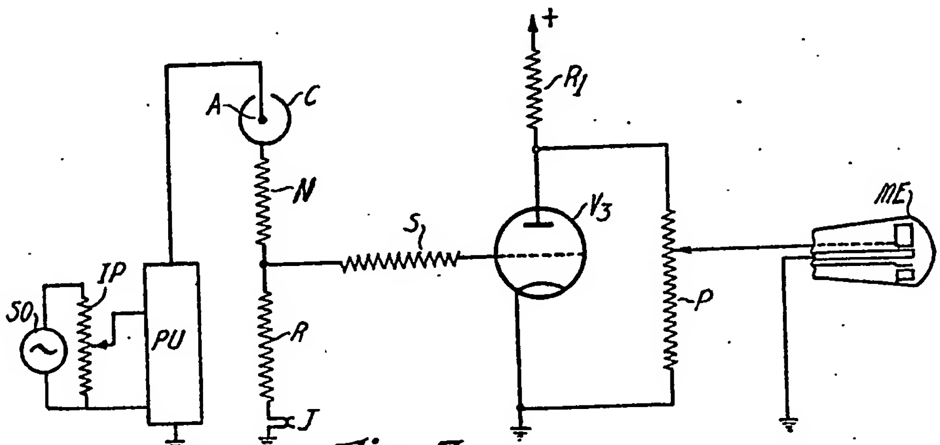

Fig. 7.

Malby & Sons, Photo-Litho.